# Draft Final Sampling Program to Determine Extent of World Trade Center Impacts to the Indoor Environment

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**BACKGROUND:** This proposal is the result of ongoing efforts to monitor the current environmental conditions for residents and workers impacted by the collapse of the World Trade Center (WTC) towers. In March 2004, EPA convened an expert technical review panel to guide and assist the Agency in its use of available exposure and health surveillance databases and registries to characterize any remaining exposures and risks, identify unmet public health needs, and recommend any steps to further minimize the risks associated with the aftermath of the WTC attack.

The WTC Expert Technical Review Panel has met periodically in open meetings to interact with EPA and the public on plans to monitor for the presence of WTC dust in indoor environments and to suggest additional evaluations that could be undertaken by EPA and others to evaluate the dispersion of the plume and the geographic extent of environmental impact from the collapse of the WTC towers.

The panel was charged, in part, with reviewing data from post-cleaning verification sampling to be done by EPA in the residential areas included in EPA's 2002 Indoor Air Residential Assistance Program and to verify that recontamination has not occurred from central heating and air conditioning systems. With the assistance of Westat, a contractor in the field of statistics, EPA developed a sampling plan to evaluate whether apartments previously cleaned in EPA’s Region 2 clean and test program had become recontaminated. The EPA proposed plan was debated by the panel, and most panel members believed that an alternate study to test for “contamination” rather than "recontamination" should be conducted instead.

Using a peer review contract, EPA solicited comment from non-panel experts on the use of asbestos as a surrogate for determining risk from other contaminants and provided a report on those comments back to the panel. The non-panel experts generally supported the use of asbestos as a surrogate, but encouraged the concurrent testing for lead. Many individual members of the panel, however, did not support the position that asbestos was an appropriate surrogate in determining risk for other contaminants.

Subsequent discussions led to the concept that a WTC signature exists in dust and that sampling could focus on determining the presence of that signature, as well as the levels of contaminants of potential concern as a basis for determining the extent of WTC collapse contamination in indoor environments. The initial thought was that a signature could be developed for both the dust generated by the collapse and particulate matter generated by the fires which burned into December of 2001. However, it now appears that it will only be feasible to develop a signature for the collapse.

This draft final plan describes the approach to be used to evaluate the presence and levels of contaminants of potential concern in buildings in lower Manhattan, including contaminants that could be markers for WTC building collapse dust. This plan is a modification of an earlier version announced in the Federal Register in October 2004. This draft final plan reflects appropriate elements from the comments received from the public, the individual members of the WTC expert technical review panel and subsequent discussion and review by EPA staff. A primary objective of this study will be to determine the geographic extent of WTC building collapse dust, and plans call for sampling beyond Canal Street to as far north as Houston Street in lower Manhattan, as well as into Brooklyn.

**OBJECTIVES:** Concurrent efforts have the following objectives –

(1) To estimate the geographic extent of WTC contaminants of potential concern (COPC) resulting from the building collapse plume by surveying residential and non-residential buildings in lower Manhattan and a portion of Brooklyn that agree to participate, and to provide a cleanup when appropriate;

(2) To relate results of the survey to building cleaning history, construction, and to the role of central heating, ventilation, and air conditioning (HVAC) if the information collected will support such an analysis;

(3) To provide the data necessary to determine if a Phase II sampling should proceed, which will test for the presence of collapse residues in areas beyond the boundaries of the areas currently tested, and to provide the data necessary to determine whether and what further actions are warranted; and

(4) To validate a screening method to identify WTC dust.

## APPROACH:

## I. GEOGRAPHIC EXTENT SURVEY

**A. <u>Overview</u>:** A primary objective of this sampling program will be to estimate the geographic extent of WTC collapse residues in a sample of buildings that agree to participate. Success in meeting this objective is contingent on developing a "signature" for WTC dust residue and the availability of a representative sample of buildings to provide sufficient coverage of the area to be studied**.** If a sufficient number of buildings do not agree to participate when selected, it may not be possible to satisfactorily estimate the extent of contamination with an adequate degree of confidence**.** An additional sampling objective is to attempt to ascertain the relationship between measurements and building cleaning history, construction, and the role of HVACs in the potential recirculation of WTC dust. Based on an evaluation of the results, EPA will determine if a second phase of sampling should be extended into other areas. EPA will also clean up building units and buildings found to have contamination above specified benchmarks in association with WTC dust; and the results will provide a basis for a decision regarding the need for more extensive clean up in areas determined to be affected by the collapse. The intent is to characterize entire buildings by sampling a number of units within each building selected. The area of sampling extends throughout lower Manhattan to Houston and Clinton Streets, and across the East River into a portion of Brooklyn. This area is more than double the size of the area included in the initial dust cleanup program conducted in 2002.

The “target population” from which the sample will be drawn is described below. For purposes of the objectives stated above, these buildings can also be characterized with regard to potential exposures – whether they are residential or non-residential, and non-residential mostly denotes buildings that house commercial or workplace environments. Some buildings may have both residential and non-residential spaces. A list of all buildings in the study area has been compiled. A statistical probability survey design will be used to identify buildings to sample, and then the participation of these buildings will be sought. Statistical procedures will be used to select alternate buildings if any initially selected building is unwilling to participate. Complete participation of each building included in this survey is required, meaning that at least one unit on every other floor within these buildings must be made available for sampling. Only with this level of participation can the survey be characterized as a “building survey.” As discussed below, a procedure to sample numerous “units” within the building will allow for an adequate building characterization.

**B. Sampling Design:** A probability survey design methodology referred to as spatially balanced sampling (Stevens and Olsen 2004) will be used to select a sample of buildings from the list of all eligible buildings. Spatially balanced sampling was developed as a powerful and flexible technique for selecting spatially well-distributed probability samples with wide application to sampling of environmental populations. The spatially balanced sampling methodology has been applied successfully to the sampling of lakes, rivers and streams and other environmental sampling applications in which selection of a probability sample that provides balanced coverage over a specified geographic area is required.

The buildings to be sampled in lower Manhattan and a portion of Brooklyn bordering the East River constitute a finite population of distinct units that occupy fixed locations specified by two-dimensional coordinates. The geographic coordinates for each building are key to the sample selection process. For the selection of buildings in this survey, two stratification variables were used: presence in an “EPIC” zone (these zones were developed by EPA’s Environmental Photographic Interpretation Center, see figure 2), and whether or not the building was breached by the collapse of the towers. These stratification variables are described below.

In order to complete the spatially balanced selection of buildings for the sampling area, the following will be accomplished:

(1) Identify the geographic area for sampling: Figure 1 shows the area that is included in this survey. It is bounded on the north by Houston Street, on the east by Clinton Street, and it

extends into Brooklyn. Figure 2 displays this area on a color-coded map.

(2) Identify buildings eligible for sampling: A complete list of all buildings in the sampling area has been developed. This list was developed by matching building footprint information provided by the NYC Department of Information Technology and Telecommunications with address, age and usage information obtained from the NYC Department of Housing Preservation and Development. Table 1 provides summary statistics for all buildings in all strata from the survey (see next section for strata definitions). Table 2 describes all the elements in this building database, and Table 3 provides building classifications for this database.

(3) Assign each building to a stratum: Once buildings eligible for sampling are identified, they must be assigned to a stratum. First, stratification variables must be defined. Two stratification variables were developed for this study. One is whether or not the building was "breached" by the collapse of the WTC towers. A survey of lower Manhattan buildings was performed by the NYC Department of Buildings shortly after 9/11. Buildings with structural damage, or whose glass was not intact were considered to be breached. Buildings with intact glass and buildings not inspected beyond the survey area were classified as not breached. Therefore, every building in the data base was described as either "breached" or "not breached." The second stratification variable used is known as "EPIC" zones. These zones were developed by EPA's Environmental Photographic Interpretation Center (EPIC, 2004). By examining satellite photography and other evidence, this organization determined the extent of deposition of WTC dust and debris. The ground dust/debris boundaries shown in Figure 2 were derived from the analysis of multiple images taken between September 11 and September 13, 2001. As can be seen in Figure 2, "confirmed dust/debris" areas extend to approximately Chambers Street, "probable dust/debris" areas extend to approximately Canal Street, and "possible dust/debris" areas extend to approximately Spring Street on the West side near the Holland Tunnel. The "confirmed dust/debris" area is the area that EPA believes was most heavily impacted by the dust generated when the towers collapsed. For purposes of this study, the categories of "probable" and "possible" were combined into one category. A third category of "no visible impact" includes all areas within the study area that were neither "confirmed" or "probable/possible" for visible dust. A fourth category includes all buildings in the Brooklyn portion of the study area. These stratification variables are the basis for defining five strata: confirmed-breached, confirmed-not-breached, probable/possible, no visible impact, and Brooklyn.

(4) Determine survey design to be used: Stevens and Olsen (2004) describe the methodology for selecting a spatially-balanced sample. Conceptually, the process guarantees that every sample that is selected exhibits a spatial distribution similar to that of the entire set of buildings in the study. For example, for the stratified design of this sampling program, the spatially-balanced property guarantees that the buildings selected within a stratum have a similar spatial distribution to that of all buildings within the stratum. In general, a sample that is spatially balanced is likely to be more "representative" of the population of buildings than a simple random sample. This is due to the fact that a simple random sample of buildings in an

area may result in a sample that does not include some subsets of the overall area because simple random sampling may result in sample buildings "clumping" in certain areas.

(5) Construct a list frame: A list of all buildings in the study area is constructed. This is referred to as the "frame." In addition to a unique building identifier, the list includes x- and y-geographic coordinates of the building centroids and a stratum value for each building (confirmed-breached, confirmed-not-breached, probable/possible, no visible impact, or Brooklyn). To be compatible with software used to select spatially balanced samples, the frame is defined as a Geographical Information Systems shapefile.

(6) Sample sizes: The stratified spatially-balanced design includes five strata, as noted above. A sample size of 30 spatially balanced buildings will be selected within each stratum. This results in a total sample size of 150 spatially balanced buildings. The number of units within buildings that will be selected cannot be ascertained until the actual buildings to be sampled are selected. Given the multitude of buildings within the stratum and the desire for timely implementation of this sampling plan, EPA believes that sampling data generated from 30 spatially balanced buildings per stratum will allow for a reasonable estimation of the geographic extent of WTC COPC resulting from the building collapse plume and determination of what further actions may be warranted. Short of sampling a much larger portion of the almost 7,000 buildings across the five strata, EPA acknowledges that these determinations cannot be made with certainty but it is critically important to begin generating and evaluating data as soon as possible and in a manageable manner. In the event that sampling at 30 buildings in a stratum is not possible, decisions will be required as to whether to proceed with sampling and how the results might be used.

EPA further believes that achieving access to sample fewer than 20 spatially balanced buildings per stratum would be insufficient for allowing reasonable determinations as described above. In the absence of access to sample at least 20 spatially balanced buildings per stratum, EPA will offer a test and clean, if necessary, program targeted at the area of "confirmed dust/debris" described above. The results from sampling in this program will be considered by EPA, along with previously collected ambient monitoring data, modeling results, and EPA's own analysis of the sampling results, to make recommendations about expansion of the sampling areas or more general cleanup activities. Source attribution will also be considered as described below. The same decision criteria for activities following sampling with a validated method to identify WTC dust in indoor dust samples will be used.

(7) Select sample for design: The psurvey.design library for the R Statistical software is used to select a sample of buildings for the design. The spatially-balanced sample selection procedure of Stevens and Olsen (2004) is based on the shapefile list frame and the specified design, and is implemented using the psurvey.design library for the R Statistical software (R and the library are available free of charge at http://cran.us.r-project.org/). The sample selection creates an ordered list of buildings that are assigned a unique sample identification number (siteID) for each building in the sample. This siteID will be critical during the implementation of the design, especially since buildings selected may not be available for sampling due to the

building owner not agreeing to participate in the study. Figure 3 shows an example sample selection for a spatially-balanced random sample of the study area.

(8) Replacement of buildings: Buildings selected in the sample must be evaluated to determine if they are willing to participate in the study. We anticipate that some buildings will not participate and that in order to maintain the desired sample size, replacement buildings will be needed. The spatially-balanced survey design will address this by selecting an over-sample of buildings that can be used as replacements. This is a standard statistical procedure to compensate for non-response in surveys. These buildings are identified as oversample sites and included in the sample selection process order to maintain the spatial balance of the sample.

(9) Selection of units: Units on alternating floors will be selected. These units should be facing the World Trade Center site, and/or units served by a HVAC. The intent behind this procedure is twofold: to identify and sample the units most likely to have been impacted by the collapse plume, and to sample enough units within the building so as to be able to adequately characterize the building as a whole. Units facing the World Trade Center site are those which are the most likely to have become contaminated based on their orientation with respect to the collapse plume as might be units with air supplied through a similarly impacted HVAC which serves their units. There may be reason to deviate from this procedure to, for example, sample only one unit in a single story building.

**C. Approach to Building Characterization:** All buildings in the sample evaluated for use will have a number of characteristics recorded. A major use for the information is to evaluate whether differences exist between buildings that agree to be sampled and buildings that do not. If differences do exist, additional statistical analyses may be completed to adjust for the differences. Building characteristics that may be relevant are described below. This section provides an overview of the strategy to characterize units within buildings, the whole building, and HVACs within buildings, if present. The Quality Assurance Project Plan (QAPP) describes in detail the protocol for selecting units within buildings to sample, how to determine where and how much to sample within units, and how to sample HVACs.

In order to gain sufficient coverage of each building, an appropriate number of samples will be collected based on the square footage on each floor, and the number of floors in the building. Therefore, it is possible that taller buildings or buildings with a large footprint may receive more representation in the results in terms of numbers of samples. Adjustments may be required to account for location so that buildings with more data do not misrepresent spatial patterns.

A “unit” generally denotes a reasonably well defined section of a floor that will be different for each building and building type. For example, a unit within a school could be a classroom, within a residential building could be an apartment, and within an office building could be an area including cubicles and private offices. Priority in unit selection will be given to the units closest to Ground Zero (i.e., the ones most nearly facing Ground Zero) and/or served by a HVAC.

Three sets of dust samples will be taken within each unit: 1) three or more samples at locations where dust-related exposures are likely to occur, such as in elevated horizontal surfaces (e.g., desk or table tops) and floors; 2) three or more samples at locations where WTC dust may have accumulated but has not frequently been cleaned, such as on top of cabinets; and 3) a single composite sample from "inaccessible" locations where cleaning is unlikely, such as behind a refrigerator. The first set of samples will be termed, "accessible" samples and the second, "infrequently accessed" samples, the third "inaccessible" samples. Samples from the first two locations will be taken by wipes and microvacs. These samples will yield results in load (weight or fibers per unit area) and will be compared to benchmarks.

The sample from the third set of locations ("inaccessible") will be bulk dust samples or collected by HEPA vacuums and will yield results in concentration (weight or fibers of contaminant per weight of sample). The locations of many of the inaccessible areas do not lend themselves to obtaining load samples (mass per unit area) that could be related to the benchmarks. Concentration (weight per weight) of a contaminant in settled dust is a poor indicator of risk. An environment with little dust would not pose a risk even if there was a high concentration of the contaminant in the small amount of dust. Therefore, the "inaccessible" area sample results will be used for signature screening and considered with modeling and monitoring results in determining the geographic extent of the distribution of dust from the WTC collapse. "Inaccessible" area sample results will not trigger a cleaning.

Wipe samples will be analyzed for the COPC lead and polycyclic aromatic hydrocarbons (PAHs), microvac samples will be analyzed for the COPC asbestos and man-made vitreous fibers (MMVFs); and bulk dust and HEPA vacuum samples will be analyzed for the COPC and to screen for the presence of WTC dust. Wipe and microvac samples will be taken in proximate locations, so that for each location sampled within a unit, there will be measurements of the four COPC. Again, further detail on the strategy for unit selection, and then to select locations within units to sample are provided in the Quality Assurance Project Plan.

The analytical results from these samples will be used to determine whether or not a cleaning will be offered to the occupant or owner of the unit being tested. Results from all units of a building will be used to determine whether a full building cleanup will be offered, and results from the study as a whole will be used to determine what further activities with regard to sampling or cleanup are warranted. Details on the criteria used to make these decisions are described in Section G below.

Specific building and space characteristics will be gathered in order to aid in understanding the results. The information will be gathered using preprinted checklists which will record:

**<u>Descriptive information</u>**
*Building age and type
*Location of floors sampled per bldg
Number of rooms sampled per floor
Square footage of floors and of space sampled per floor
*Location of space sampled on floor
Cleaning and renovation history since WTC collapse
*Type, number, age of windows in spaces sampled
*Number of window or wall HVAC units
Cleaning and replacement history of window or wall HVAC units since WTC collapse
*Visible WTC dust reported present in unit
Reported cleaning frequency and date of last cleaning prior to sampling
Carpet present
Carpet cleaned or replaced since WTC collapse

**<u>Attribution Information</u>**
Location and amount of friable asbestos material present in sampled space
Location and area of MMVF present, i.e ceiling tiles, pipe insulation, spray on fireproofing
Location and amount of chalking/peeling paint present
Current use of space
Significant particulate or combustion sources within sampling area, e.g. fireplace, stove, occupant smokes
Significant particulate or combustion sources within or adjacent to the building, e.g. above fast food restaurant, adjacent to emergency diesel generator exhaust

**<u>Central HVAC Design Information</u>**
*Location of air inlets
Location of filters or other air cleaning devices in system
Number and Location of HVAC return ducts in sampled space
Central HVAC cleaning and replacement history since WTC collapse

The "*" variables will be considered in a secondary data analysis. We will determine the degree of correlation between exceedances and these variables.

**D. <u>Contaminants of Potential Concern</u>:**

Contaminants of Potential Concern (COPC) which will be measured in this program include asbestos, man-made vitreous fibers (MMVF), PAHs and lead. A total of 6 COPC, including these four as well as silica and dioxin, were identified by EPA Region 2 during 2002. A full discussion of these 6 COPC can be found in *World Trade Center Indoor Environment Assessment: Selecting Contaminants of Potential Concern and Setting Health-Based Benchmarks* (EPA, 2003a; referred to as the COPC Report below). The COPC Report includes justifications for selecting these WTC-related contaminants as COPC, and also the basis for the health-based benchmarks for these contaminants in indoor air and settled dust. The COPC Report, and the COPC benchmarks developed in it, was peer reviewed. EPA's preferred approach to establishing cleanup benchmarks is risk-based. As the public and some members of the panel have expressed strong opinions against sampling for asbestos and MMVF in air, and inhalation is the pathway of concern for these COPC, the air concentration benchmarks in the COPC Report for these COPC are not appropriate for current purposes. The public and some members of the panel also expressed concern that an earlier EPA proposal to use 3 times a background dust concentration as a clean-up benchmark may not be sufficiently protective. Also, EPA believes it would be difficult to establish a statistically robust background data set to develop this 3 times background benchmark, due to the number and variety of buildings in the study area. For these reasons, EPA has had to develop new cleanup benchmarks for this study.

Since only dust will be measured in this program, of particular note is the establishment of risk-based benchmarks for dust for two of the COPC - PAHs and lead. These benchmark values, at 150 $\mu g/m^2$ for PAHs and 40 $\mu g/ft^2$ for lead, will be used in post-sampling decision making regarding cleanup activities (see section below on Decision Criteria). The PAH benchmark is health-based; it was developed as part of the earlier COPC effort (EPA, 2003a), and its value was supported in the peer review. The lead benchmark was developed by the United States Department of Housing and Urban Development (HUD). Health-based benchmark values for the other COPC were established for sampling in air, but not for dust, in the COPC Report.

It should be noted that the health-based benchmark for lead in settled dust in the COPC Report was based on the HUD screening level (25 $\mu g/ft^2$) for accessible floor space. The HUD screening value was consistent with the purpose of the wipe sampling performed in EPA's 2002 WTC Indoor Air Residential Assistance Program (i.e., to determine the efficiency of the cleaning techniques rather than as a action level for triggering a cleanup). The benchmarks developed for the WTC sampling program may serve as action levels for cleanup. As such, the health-based benchmark for lead should be consistent with the dust hazard/clearance standards in the HUD regulation. Therefore, the criteria established by HUD will be followed:

Floors = 40 $\mu g/ft^2$
Window Sills = 250 $\mu g/ft^2$
Window Troughs = 400 $\mu g/ft^2$

As noted earlier, individuals on the WTC Expert Technical Review Panel have recommended against the use of air sampling for detecting WTC related fibers (asbestos and MMVF) in the indoor environment as part of the sampling program. Individual members of the panel are of the opinion that settled dust provides a better medium for identifying the presence of residual fibers, as well as offering a simpler and less intrusive sampling protocol. The absence of air sampling, however, creates a data interpretation void because unlike air, health-based benchmarks for asbestos and MMFV in settled dust were not included in the COPC report.

Earlier versions of this sampling plan discussed the capacity of asbestos and fibrous glass to re-entrain in indoor air, and the possibility of developing settled dust benchmarks based on an inhalation pathway. However, development of a "k" factor, which is an empirical factor relating a dust concentration to an air concentration, was not pursued for this sampling plan based on recommendations of individual members of the expert technical review panel, who cited the considerable uncertainty inherent in characterizing the relationship between fiber loads in indoor air and settled dust. Factors contributing to this uncertainty include surface porosity, activity patterns, fiber dimensions, room volume and air exchange rates.

In the absence of asbestos air sampling, and given the uncertainty associated with the modeling of air concentrations based on asbestos loads in settled dust, a weight-of-evidence approach has been developed for establishing a benchmark for asbestos in settled dust. The American Society for Testing and Materials (ASTM) has published an "Experience" Standard based on the work of Millette and Hays (1994) for interpreting asbestos loads (structures per unit area) in settled dust. The standard pertains to samples obtained by the microvac (ASTM 5755) sampling technique. According to this standard:

1,000 S/cm$^2$ = "Low" concentration
10,000 S/cm$^2$ = "Above Background" concentration
100,000 S/cm$^2$ = "High" concentration

[Note: This document references two types of fibrous materials, asbestos and man-made vitreous fibers (MMVF). These materials have alternately been described as fibers or structures in various citations in the literature. For the purposes herein, the term "structures" refers specifically to asbestos as analyzed by transmission electron microscopy (TEM), and is consistent with the counting procedures detailed in the Asbestos Hazard Emergency Response Act (AHERA). MMVF and asbestos analysis by phase contrast microscopy (PCM) are referred to as "fibers."]

The asbestos contamination in the town of Libby, Montana offers additional information for consideration in the development of a benchmark for asbestos in settled dust. At that site, an action level of 5,000 S/cm$^2$ in generally accessible areas has been established for triggering a cleanup in a residential dwelling.

Finally, there has been discussion at the panel meetings relating to using a multiple of background for setting a benchmark for asbestos in settled dust. A factor of 3X had been proposed in the October 2004 draft WTC sampling plan. EPA's WTC Background Study (2003) reported a mean value of approximately 2,250 S/cm$^2$ for residential dwellings sampled by the microvac method.

Based on the above discussion, a benchmark of 5,000 S/cm$^2$ is proposed for asbestos in settled dust. This value is the approximate midpoint in the ASTM Experience Standard that is bounded by values considered "low" and those considered "above background;" it is consistent with the action level used for residential cleanups in Libby, Montana; and, it represents a value that is approximately two to three times background as characterized in EPA's WTC Background Study.

A benchmark for MMVF in settled dust was developed with consideration given to both its toxicity and background levels relative to asbestos. In one respect, it would be intuitive to establish a value that is less stringent than the number (5,000 S/cm$^2$) developed for asbestos. This is based on the understanding that, on a fiber-for-fiber basis, asbestos is viewed as more hazardous than fibrous glass (a prototypical form of MMVF). This is reflected in the OSHA Permissible Exposure Limit (PEL) which is an order of magnitude more stringent for asbestos (0.1 f/cc vs 1.0 f/cc - PCM) and the greater than order of magnitude difference in the WTC heath-based benchmarks established for asbestos (0.0009 S/cc - PCMe) and fibrous glass (0.01 f/cc). Conversely, the background levels of MMVF found in EPA's WTC Background Study are more than an order of magnitude lower than the levels reported for asbestos. However, there were fewer MMVF samples (compared to asbestos) obtained in the WTC Background Study lending greater uncertainty to the reported value. Also, unlike asbestos, there is little in the scientific literature relating to MMVF loads (fibers per unit area) in settled dust. Based on the discussion above, a case could be made for setting the MMVF benchmark in settled dust either considerably higher (based on toxicity) or lower (based on background) than the value established for asbestos. It is proposed that the value applied to asbestos, 5000 S/cm$^2$, also be applied to MMVF. This value was specifically developed for this program, is not risk based and is not intended for use in any other context.

**Silica, Dioxin and Mercury:** Silica and dioxin, selected as COPC by EPA Region 2 in 2002, are not included in this program. The COPC Report based the inclusion of dioxin as a COPC on the levels found in the ambient air in the weeks/months after September 11, 2001, when combustion processes were still taking place. At the time the COPC Report was finalized, limited preliminary data on dioxin wipe samples (approximately 200) in lower Manhattan residential dwellings were available. These data indicated a preponderance of non-detects. However, the aforementioned presence of dioxin at elevated concentrations in the ambient environment post 9/11 was sufficient basis for including dioxin as a COPC. Dioxin concentration in ambient air has since returned to background levels. In addition, the complete data set of over 1,500 dioxin wipe samples obtained from residential dwellings in lower Manhattan revealed only 8 exceedances of the health-based benchmark of 2 ng TEQ/m$^2$ (TEQ is an acronym for Toxic Equivalents which is a cumulative measure of toxicity for a suite of dioxin and furan compounds that are dioxin-like). Given this evidence, additional sampling for dioxin is not included in this program.

Crystalline silica was included as a COPC based primarily on its relative abundance (on a percent weight basis) in bulk and settled dust samples taken in both outdoor and indoor locations during the Fall of 2001. At that time, the amount of residual dust/debris in Lower Manhattan was significant. The concern with the presence of crystalline silica in dust/debris relates to its ability to become airborne and, ultimately, inhaled. Sampling conducted in the Fall of 2001 (ATSDR/NYCDOHMH, 2002) demonstrated measurable levels of crystalline silica in indoor air when high concentrations of crystalline silica were observed in settled dust (up to 31% by weight). However, the ATSDR/NYCDOHMH report concluded, "*Short-term exposure to quartz (crystalline silica) even for a continuous year of exposure at the highest estimated air concentration, is not expected to result in any adverse health effects. Assuming worst-case theoretical assumptions, the estimated quartz (crystalline silica) levels measured cannot rule out adverse health effects from chronic exposures (i.e., 30 years). For individuals who conduct* *frequent cleaning of their residences, as recommended in this report, or participate in the U.S. Environmental Protection Agency cleaning/sampling program, it is unlikely that their exposure would resemble these worst-case conditions."*

The significant reduction in residual dust/debris (and therefore, crystalline silica) in both the outdoor (e.g., cleanup of Ground Zero) and indoor (e.g., EPA's 2002 WTC Indoor Air Residential Assistance Program) environment over the past three plus years would further reduce the potential for this mineral to pose a potential chronic health threat. Additionally, sampling for relatively low levels of crystalline silica is confounded by the fact that this mineral is a major component of the earth's crust (Casarett & Doull, 1996). This fact is evidenced in the following statement, from the COPC Report: *"Since quartz (crystalline silica) is a common material in sand, finding this mineral in a city where there is a great deal of concrete is not unusual."* Consequently, sampling for crystalline silica in settled dust is not included in this program.

Mercury has been the subject of much debate relating to its exposure potential post 9/11. Previously, there have been reports of elevated mercury levels in both biological and environmental samples. In the first case, medical monitoring of Port Authority officers assigned to the WTC site registered marginally elevated mercury blood levels in 4 officers. An investigation (NYCDDC, 2002) revealed no elevation in urine mercury levels in this group, nor could an environmental source be identified. It was determined that the officers were not dietary restricted for known sources of mercury (e.g. fish) prior to screening. Repeat sampling under controlled dietary conditions demonstrated blood mercury levels to be within normal limits. Additional evidence of negligible occupational exposure to mercury vapor during the WTC rescue /recovery operation is provided by a study in firefighters. Edelman, et al. (2003) reported only one elevated (>35 ug/gm creatinine) urine mercury level in 10,000 samples.

An environmental investigation by I.H. Consultants Inc. (Singh, 2002) in various indoor and outdoor locations in Lower Manhattan identified mercury vapor levels orders of magnitude above urban background concentrations. This investigation was performed with a Jerome Meter which is a particularly poor instrument for measuring low-level airborne mercury. The mercury concentration in ambient air in urban environments is generally below 20 ng/m$^3$ (Johnson, 2002). The detection limit for the Jerome Meter is 3,000 ng/m$^3$. Many of the elevated levels, relative to background, detected in the Singh report (2002) were at or close to the detection limit of the Jerome Meter. A subsequent investigation by Johnson (2002) in the same locations sampled by Singh was performed using a Lumex RA-915 mercury vapor analyzer. The detection limit for this instrument is 2 ng/m$^3$ (1,500X more sensitive than the Jerome Meter). None of the elevated readings reported by Singh could be replicated with the Lumex. In over 100 individual samples, the highest concentration detected was 319 ng/m$^3$ - a reading that is an order of magnitude below the detection limit of the Jerome Meter. EPA's chronic reference concentration (RfC) for mercury vapor is 300 ng/m$^3$. Evaluation of these data along with additional data sources detailed in the COPC/Benchmarks Report (2003), including preliminary mercury wipe sampling results from EPA's 2002 WTC Indoor Residential Assistance Program, formed the basis for not including mercury as a WTC COPC. At the present time, the complete wipe sampling data set is available, and it contains over 1500 samples. Results show that there were only 6 exceedances of the benchmark of 157 $\mu g/m^2$ and the highest single value was 248 $\mu g/m^2$.

RJ Lee Inc.(2003/2004) has performed extensive environmental sampling in the former Deutsche Bank at 130 Liberty Street. This building, now slated for deconstruction, was heavily impacted by the WTC disaster. Mercury was sampled in settled dust by wipes and in indoor air by a Lumex direct reading mercury vapor analyzer. Over 2,000 wipe samples were obtained. The maximum recorded value (600 $\mu g/m^2$) exceeded EPA's health-based benchmark for mercury (157 $\mu g/m^2$) by approximately a factor of four. However, the average mercury wipe sample was less than 20 $ug/m^2$, well below the health-based benchmark. RJ Lee Inc. computed 95% upper confidence limits (UCL, and defined on page 17) on the mercury wipe sampling on each of the building's forty floors. None of the individual 95% UCLs by floor exceeded the health-based benchmark, indicating that area-wide mercury did not pose a significant exposure threat from contact with residual dust. The air sampling performed by RJ Lee Inc. only recorded significantly elevated levels of mercury in air, under circumstances unlikely to be encountered in an occupied space, such as torch cutting of steel. All ambient air samples obtained in general office space were below EPA's chronic RfC for mercury.

Results of ongoing ambient, outdoor, mercury vapor monitoring at a site (4 Albany Street) adjacent to 130 Liberty Street has consistently demonstrated levels to be well below EPA's RfC of 300 $ng/m^3$.

**E. <u>Analytical Methods and Sampling Protocols</u>:** These are shown in Table 4. Lead will be sampled with wipes, as the health-based benchmark for lead is based on a wipe sampling method (EPA, 2003a). PAHs will also be sampled by wipes. The health-based benchmark for PAHs was developed based on exposure and health-impact considerations and was not specific to a sampling method (EPA, 2003a). It is expected that wipe sampling will capture the PAHs that exist on dust particles and also PAHs that could be trapped on oily films that may be present on non-porous surfaces like table or countertops. As such, a wipe sampling approach for PAH measurement is expected to provide a conservative (i.e., as high as possible) estimate of the PAHs available for exposure. The remaining COPC, asbestos and MMVF, will be sampled using a microvac. The decision to use a vacuum approach for these COPC in contrast to a wipe method is for the purpose of comparison to an ASTM experience standard for asbestos. A HEPA vacuum will also be used by sampling teams, in order to sample for the WTC dust screening components. The detailed protocols describing procedures to select units within buildings, procedures to identify locations within units to sample, procedures to sample using wipes, microvacs and HEPA vacuums and the analytical methods are contained within the draft QAPP for this program.

**F. <u>Heating, Ventilation, and Air Conditioning (HVAC) Sampling</u>:** In order to characterize central HVAC units in buildings which have full or partial central HVAC units ("full" is defined as units serving both common areas and individual apartments, offices, etc; while "partial" is defined as units serving only common areas while apartments or offices have individual units), samples will be taken in: 1) outdoor air inlets to HVAC; 2) air mixing plenums serving sampled floors; 3) HVAC outlets discharging to locations where COPC samples are taken; and 4) HVAC filters will be sampled. As is the case with the inaccessible areas, these areas do not lend themselves to obtaining load samples (mass per unit area) that could be related to the benchmarks. Concentration (weight per weight) of a contaminant in settled dust is a poor indicator of risk. A location with little dust would not pose a risk even if there was a high concentration of the contaminant in the small amount of dust. Therefore, the COPC sampling results for HVACs will not be used to trigger a cleaning. The full protocol for HVAC sampling is provided in the draft QAPP.

**G. <u>Decision Criteria for Activities Following Sampling</u>:** The indoor sampling program outlined in this proposal will provide data that will be the basis for decision-making on whether to offer a cleaning to the unit being sampled, whether to offer a cleaning of the entire building being sampled, and whether to extend the area for sampling to determine the extent and magnitude of WTC dust presence. Additional sampling and/or cleaning activities within the study area might also be appropriate, but this section only outlines the process for these decision endpoints**.** A further examination of these data from the program by EPA, with appropriate input may lead to other activities.

There are two sources of information that contribute to the decision-making process for an initial unit cleaning. These are the measurements of the COPC and the determination as to whether sampled dust contains WTC dust. As discussed below, efforts to identify screening materials used to identify whether WTC dust is present within a dust sample, and to validate the method for use in this sampling program, are underway. The candidate materials identified include slag wool, gypsum and elements of concrete.

Decision criteria are required for two possible scenarios: the method validation study for identifying WTC dust is successful, or it is not.

(1) <u>The method validation study is fully successful in identifying screening materials that can identify WTC dust in indoor dust samples</u>.

Figure 4 displays a decision tree for this evaluation. It is assumed that the signature screening method study is completed and has been successful in validating a method to identify WTC dust. The theme inherent throughout this figure is that, where COPC exceed benchmarks, a cleanup will be offered to the owner or occupants for those units or buildings sampled that have the COPC associated with dust from the WTC. For buildings, the decision will be based on an examination of all the data within the building related to the WTC collapse. For units, this translates to the following: if at least one COPC sample in a unit has an exceedance of a benchmark *and* if at least one sample taken for identification of WTC dust indicates the presence of WTC dust, then a cleanup is offered. The decision for HVAC cleanup is tied to a building cleanup decision: HVACs will be cleaned if the building criteria for cleanup are met, and the WTC signature can be found in the HVAC dust samples. Specific procedures for units, buildings, and HVACs are described below.

**<u>Approach for Unit Areas</u>:** Typically, EPA would base decisions on cleanup using health-based benchmarks for concentrations of COPC. For fibrous materials, such as asbestos, the peer-reviewed benchmarks are based on ambient air concentrations. In this sampling program, the method for determining concentrations of COPC will be by wiping or vacuuming surfaces for settled dust. This has been the preferred approach for many groups in the community affected and for many members of the Expert Panel. In deference to this opinion, air sampling will not be conducted. The COPC report established health based benchmarks for asbestos and MMVF in indoor air; but not in settled dust. The amount of research necessary to establish health-based benchmark concentrations in dust for the remaining decision-making COPC precludes pursuing their derivation if the sampling program is to proceed in a timely manner. Thus, health-based benchmarks will not be available for asbestos and MMVF. Instead, "cleanup benchmarks" have been established for them. The derivation of these was described above in the COPC section; for asbestos, the benchmark is 5,000 S/cm$^2$, where the count of structures included both long (> 5 µm) and short (0.5 – 5.0 µm) fibers, and for MMVF, the benchmark is similarly 5000 f/cm$^2$. For PAHs and lead, the health-based benchmarks, 150 µg/m$^2$ for PAHs and 40 µg/ft$^2$ for lead based on wipe sampling methods, will be used as the appropriate benchmarks in this decision framework.

The WTC sampling program proposes to conduct settled dust sampling in both accessible (for current hazard assessment) and infrequently accessible (for potential contaminant reservoirs) areas. A potential hazard can occur from contaminant reservoirs in infrequently accessible areas through contamination/re-contamination of accessible areas and/or direct contact with these reservoirs. In either case, the contaminant load in these areas would need to be significantly greater than the aforementioned benchmarks to pose a hazard, since they are infrequently accessed. Accordingly, separate benchmarks in settled dust for infrequently accessible areas have been established.

**Accessible areas:** As described above, benchmarks for COPC in settled dust have been established. Because these benchmarks are based on either the potential for direct contact for ingestion toxicants (lead and PAHs) or re-entrainment potential for inhalation toxicants (asbestos and MMVF), their application is specific to contaminant loads in accessible areas that are routinely contacted (e.g., floors, counter tops, etc.). The benchmarks for accessible areas are listed below:

| | | |
|---|---|---|
| Lead | - | 40 µg/ft$^2$ |
| PAHs | - | 150 µg/m$^2$ |
| Asbestos | - | 5,000 S/cm$^2$ |
| MMVF | - | 5,000 f/cm$^2$ |

**Infrequently Accessed Areas:** The development of these benchmarks has taken into consideration re-contamination potential and direct contact. In addition, relevant guidance/regulations were reviewed to inform benchmark development. Because infrequently accessible areas (e.g., out of reach shelving, etc.) are likely to represent a considerably smaller surface area and direct contact threat relative to accessible areas, a higher level benchmark is indicated. With respect to relevant guidance/regulations, HUD provides a model for setting a two-tiered benchmark. The friction associated with the movement of lead-painted windows creates reservoirs in the window troughs which can serve as a source of contamination to other areas as well as a significant, although infrequent, source of direct contact exposure. The HUD clearance standard for window troughs is 400 $\mu g/ft^2$, a factor of ten greater than the standard for floors (40 $\mu g/ft^2$). It is therefore proposed that the HUD clearance standard for window troughs serve as the benchmark for evaluating wipe samples obtained from infrequently accessed areas that may serve re-contamination reservoirs and/or sources of heightened direct exposure. Like lead, the benchmark (accessible areas) for PAHs in settled dust is health-based and driven by the potential for children to routinely contact accessible surfaces (e.g., floors, walls, tables, counter tops, etc.). Similarly, a benchmark for infrequently accessed areas should reflect reduced direct exposure potential as well as a limited area source for potential recontamination of accessible areas. It is therefore proposed that the same order-of-magnitude factor in the HUD clearance standards for floors and window wells be applied to the PAH settled dust benchmark for infrequently accessed areas.

Benchmarks for asbestos and MMVF in settled dust for accessible areas were based in part on the ASTM "Experience Standard." The benchmark for asbestos (5,000 $S/cm^2$) was the approximate midpoint between the values ASTM established as "low" (<1,000 $S/cm^2$; i.e., unlikely to result in a significant re-entrainment potential) and "above background" (> 10,000 $S/cm^2$). The ASTM "Experience Standard" established a third value (>100,000 $S/cm^2$) equating to significant releases from source material. This value (>100,000 $S/cm^2$) is proposed as the asbestos benchmark for infrequently accessed areas. The MMVF benchmark for settled dust in accessible areas was set at the same level as asbestos; therefore, the benchmark for infrequently areas is similarly set at level proposed for asbestos (>100,000 $f/cm^2$).

The following are the proposed benchmarks for infrequently accessed areas:

| | | |
|---|---|---|
| Lead | - | 400 $\mu g/ft^2$ |
| PAHs | - | 1,500 $\mu g/m^2$ |
| Asbestos | - | 100,000 $S/cm^2$ |
| MMVF | - | 100,000 $f/cm^2$ |

**Inaccessible areas:** These areas include, for example, behind refrigerators and furniture, tops of duct runs, and other areas which are rarely cleaned, and exposure potential is expected to be low. The locations of many of the inaccessible areas do not lend themselves to obtaining load samples (mass per unit area) that could be related to the benchmarks. Concentration (weight per weight) of a contaminant in settled dust is a poor indicator of risk. An environment with little dust would not pose a risk even if there was a high concentration of the contaminant in the small amount of dust. Therefore, the COPC sampling results for inaccessible areas will not be used to trigger a cleaning. These areas are proposed to be HEPA vacuum sampled only for signature presence determination and COPC concentrations to help define plume extent.

**Approach for Heating, Ventilation, and Air Conditioning (HVACs):** HVACs are proposed to be sampled in the same manner as inaccessible areas and would only be cleaned if the signature is determined to be present in the HVAC system and a whole building cleaning is triggered based on the 95% UCL criteria (see decision tree Figure 4). As noted above we will also be collecting information on the cleaning history of HVAC systems. We will analyze the data collected on COPC concentrations in HVAC systems in conjunction with the data on plume extent to determine if any further action is warranted in systems that do not warrant immediate cleaning.

**Approach for Buildings:** The proposed decision criterion for a judgment relating to full building cleanup involves the use of a 95% Upper Confidence Limit (UCL) on a mean contaminant level. An Upper Confidence Limit (UCL) is a measure of uncertainty in an estimated mean due to sampling, measurement and other sources of variability in a set of data. The 95% UCL defines a value that will be exceeded by the sample mean approximately 5% of the time in repeated sampling. The 95% UCL is commonly employed in EPA hazardous site assessments to provide a conservative upper bound estimate on the average site-wide contaminant level. The UCL will be used in the decision process as follows: If the 95% UCL for the estimated building mean exceeds the benchmark value for a COPC, and concurrently, there is evidence of WTC dust in the building, then this may be considered to provide support for the decision to clean the building. Separate analysis will be conducted for accessible and infrequently accessed areas and each area will be compared to its own benchmarks. An exceedance of the 95% UCL in either set of areas will be the basis for offering a building clean up. Only data for units with evidence of WTC dust present will be used in calculating the UCL. However, it should be noted that source attribution will be a critical factor in determining whether to reclean after cleaning. For example if lead exceedances trigger the 95% UCL criteria as described here, a building cleanup will occur as with other COPC triggering the 95% UCL. However, a source survey will be conducted where exceedances are found and if it is found that the exceedance is due to a source within the building or adjacent to the building, no further cleaning or resampling to demonstrate clearance will be offered. Although most pertinent to lead, the same principle applies to the other COPC – if the exceedances resulting in the building cleanup can be attributed to a source within or adjacent to the building, no further cleaning or resampling to demonstrate clearance will be offered.

**Decision for Phase II:** Decisions will also need to be made once the sampling is completed relating to whether the data supports a more general sampling and/or cleanup program within a particular strata or an expansion into a Phase II program that extends beyond the borders of the current sampling effort. Decisions regarding expansion into a Phase II will be based on an examination and comparison of the data for the buildings in the sampled areas to each other and to plume modeling data from September 11, 2001. Expansion could be considered if there is ample evidence of both the presence of WTC dust as well as significant exceedances of the COPC benchmarks in areas outside of the area with confirmed or possible/probable contamination.

**Decision for Additional Cleanup:** Similarly, decisions as to whether a new general cleanup program is warranted within a stratum will be based on a careful examination of the data with particular attention to the spatial distribution of the WTC signature and exceedances. Final decisions on these post-survey activities will be made by EPA with appropriate input.

(2) If validation of a screening method to identify a “signature” is not successful, the decision for sample unit cleanup will have to rely on the levels of contaminants of potential concern alone.

The absence of a WTC signature may make it very difficult to determine the geographic extent to which WTC dust has impacted indoor environments and whether any exceedances of COPC are related to the WTC collapse. In the absence of a measure that can identify WTC dust, EPA will offer a voluntary test and clean, if necessary, program targeted at the area of “confirmed dust/debris” described above. The results from sampling in this program will be considered by EPA, along with previously collected ambient monitoring data, modeling results, and EPA’s own analysis of the sampling results, to make recommendations about sampling unit cleanups, expansion of the sampling areas, or more general cleanup activities. Source attribution will also be considered as described above.

## II. WTC SIGNATURE DUST SCREENING METHOD VALIDATION STUDY

**A. Background:** The objective of this effort is to develop and validate a means of determining whether dust sampled as part of EPA’s planned sampling program can be attributed to the collapse of the WTC towers. The concept discussed at the Expert Panel meetings was to develop a “signature” that would identify “WTC dust” as being either identified with the WTC tower collapse or originating from the fires that burned until December of 2001. EPA has been investigating the possibility of basing a fire “signature” on the ratio and mass fraction of nine different PAHs. Study of this signature has indicated two areas of concern. First, this method is not able to differentiate between PAH residues resulting from normal NY City building fires from that resulting from the WTC fires. Second, there are currently no data to show how the nine PAHs degrade with time and with exposure to extremely variable conditions. Thus, use of this screening method could potentially have a high level of false negative results. Given these issues, EPA has decided to focus its efforts entirely on a signature for the tower collapse.

. **B. Approach:** In recent months, WTC dust samples have been collected and studied to determine whether they can be described, in fact, as WTC dust. Dispersion models, photos, interviews and satellite data have been reviewed to discern buildings that were likely impacted by WTC emissions. One such building was the Deutsche Bank (130 Liberty St.) building, across from Ground Zero. This building was heavily impacted by the collapse of the towers. This building has remained unoccupied to this day, and it was believed that strategically collected dust samples within this building (i.e., those in the most obviously impacted and undisturbed areas) would still retain WTC dust three years after the collapse of the towers. To be considered useful screening materials in this sampling program, they must meet the following criteria: 1) they are present at levels unique to WTC dusts (distinct from urban dusts); 2) they are persistent for many months (not volatile); 3) they are homogeneous in WTC dust (evenly distributed through samples of WTC dust); and 4) available analytical methods are able to detect these screening materials with a small sample size, low minimum detection limit, and low interference from other dust components. Although not similarly descriptive, a fifth criterion relates to the fact that numerous samples from the overall program will ultimately be evaluated for these screening materials. As such, it is desired that analysis for these screening materials can proceed rapidly through available commercial laboratories.

In addition to the analysis of known WTC dust, background samples are being analyzed to verify that materials used for the screening method are not present at levels comparable to those levels in known WTC dust and, thereby, compromise the use of the method in identifying WTC dusts.

The overall method will be considered "valid" for use in the sampling program when it is determined that WTC dust can be identified and distinguished from background samples.

**C. Hypothesis/basis for screening method:** The hypothesis being tested during the development of the screening method is as follows: "A dust sample that contains WTC dust will have slag wool, and elements of concrete and gypsum present in 'significant quantities' when compared to typical indoor urban dust."

The definition of 'significant quantities' is currently being studied. Preliminary research shows that there is a large difference between background and WTC levels of each of the three primary contaminants listed above. Thus, it is anticipated that the quantity and/or presence of each of these materials will be used to identify WTC dust and distinguish it from background dust.

**D. Sampling and Storage:** A program to acquire indoor dust for the development and evaluation of a WTC dust screening method has been completed. Samples from more than 40 buildings have been collected for validation of the proposed method. A standard method using a HEPA vacuum collector was used by EPA to collect bulk dust samples. Samples were sealed and stored under refrigeration in a limited access area. To ensure that these important samples were properly collected, tracked, stored, and distributed, comprehensive quality assurance (QA) procedures were in place. A survey of building and sampling areas, including photos of sampling areas (if permitted by building owners) and notes on building usage are being used to identify conditions that may affect samples.

**E. Screening Method Development:** In a collaborative effort between the USGS, the EPA's National Exposure Research Laboratory (NERL), the EPA's National Enforcement Investigations Center (NEIC), and a number of experts from the commercial testing laboratory community, an analytical method has been developed to measure the presence and concentration of the screening parameters (i.e., slag wool, and elements of concrete and gypsum,) in indoor dust. This method will be reviewed by the expert panel members on the signature subcommittee prior to being used for the validation study.

**F. <u>Screening Method Validation</u>:** Five independent laboratories have been recruited for a final validation test. Each laboratory has attended a two day session during which the method was further developed and discussed, and procedures to adapt the method to suit each laboratory's equipment were determined. Following this session, the laboratories received dust samples consisting of both confirmed background samples and background samples spiked with varying amounts of WTC dust. The spiked dust contains known quantities (concentrations) of the screening materials. The labs were provided the samples "blind", thus, they do not know which samples are pure background dust, and which are the background dust samples spiked with WTC dust. The labs will have several weeks to analyze all dust samples. They were asked to provide data as to the quantity of screening materials present in the dust, and to determine whether that dust meets the criteria for identifying WTC dust as defined by the hypothesis above. The final data from all laboratories will be evaluated to determine if they were able to distinguish background samples from WTC spiked samples. In effect, the data will be evaluated to determine whether a validated marker of WTC collapse residue is available, and the lowest concentration of WTC residue that should be present in the dust for the protocol to work.

The goal is to validate a method of differentiating between samples of dust that contain residues from the WTC collapse from those that do not. However, since the three primary materials (slag wool, and elements of concrete and gypsum) identified above are all normally found in dusts present in the New York area, it is possible that the proposed screen may yield some percentage of false positive identifications of WTC dust. As long as the false positive rate is not too large, the method will be considered reasonable for use. As mentioned above, preliminary research shows that there is a large difference between background and WTC levels of each of these materials, suggesting an outcome of a low false positive rate.

The WTC signature dust screening method validation study report will be subjected to an independent external peer review by experts in this field.

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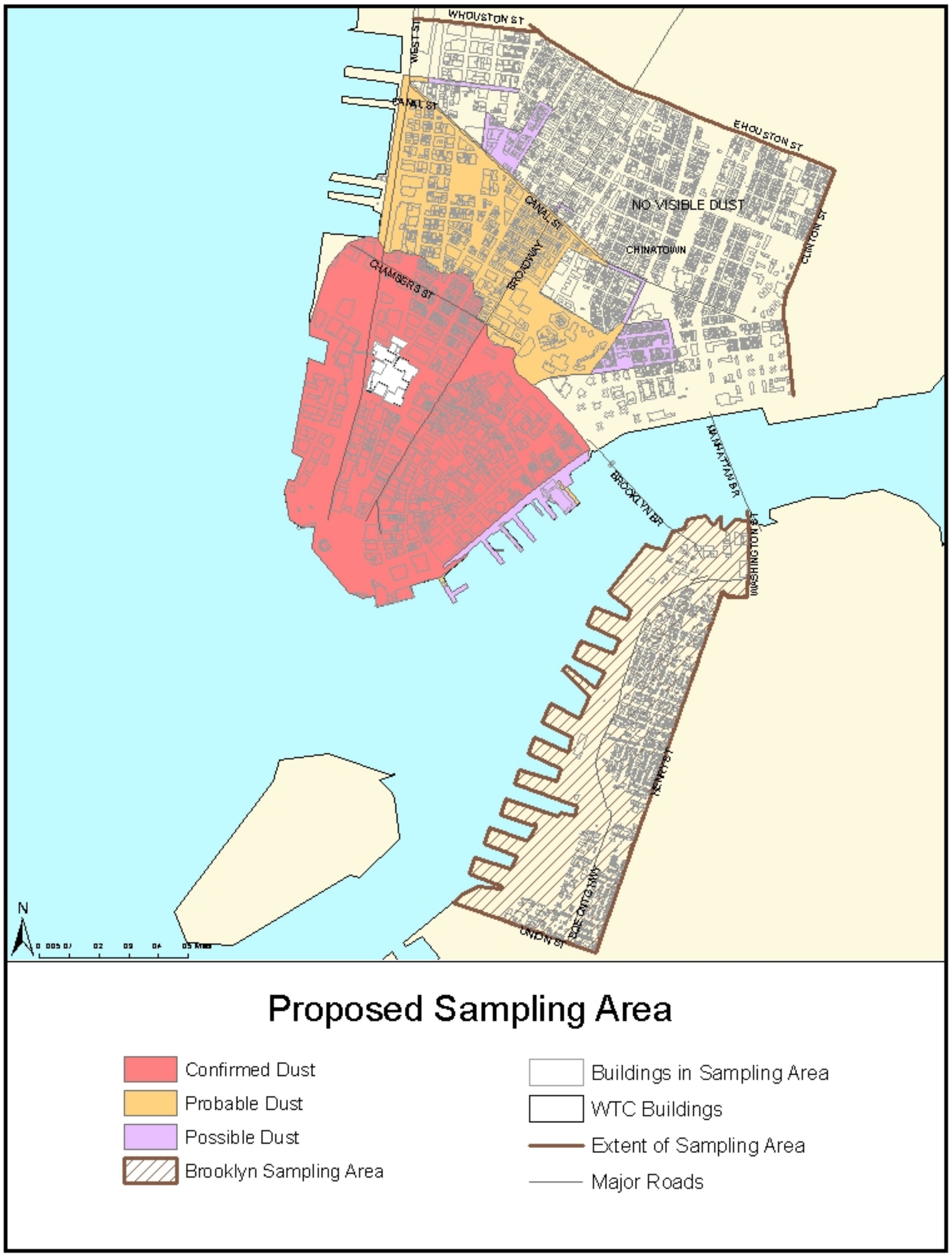


**Figure 1.** The study area of lower Manhattan bounded by Houston Street, overlain on the EPIC results which are displayed in three colors: red meaning confirmed dust/debris; orange meaning probably dust/debris, and pink meaning possible dust/debris.

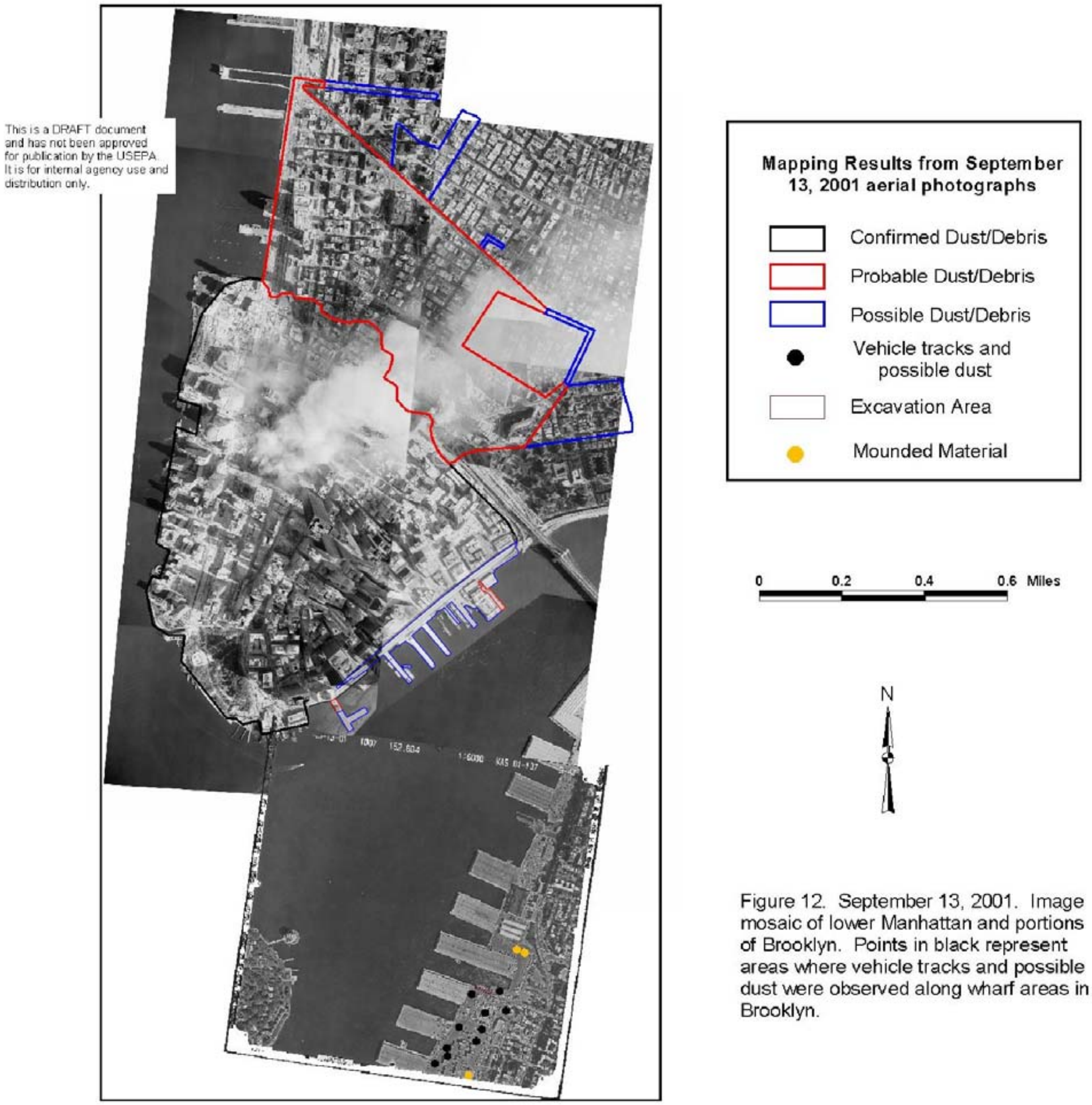


**Figure 2.** Display of boundaries of expected deposition based on analysis conducted by EPA's Environmental Photographic Interpretation Center (EPIC; this figure is updated by EPIC from the figure which appears in EPIC, 2004).

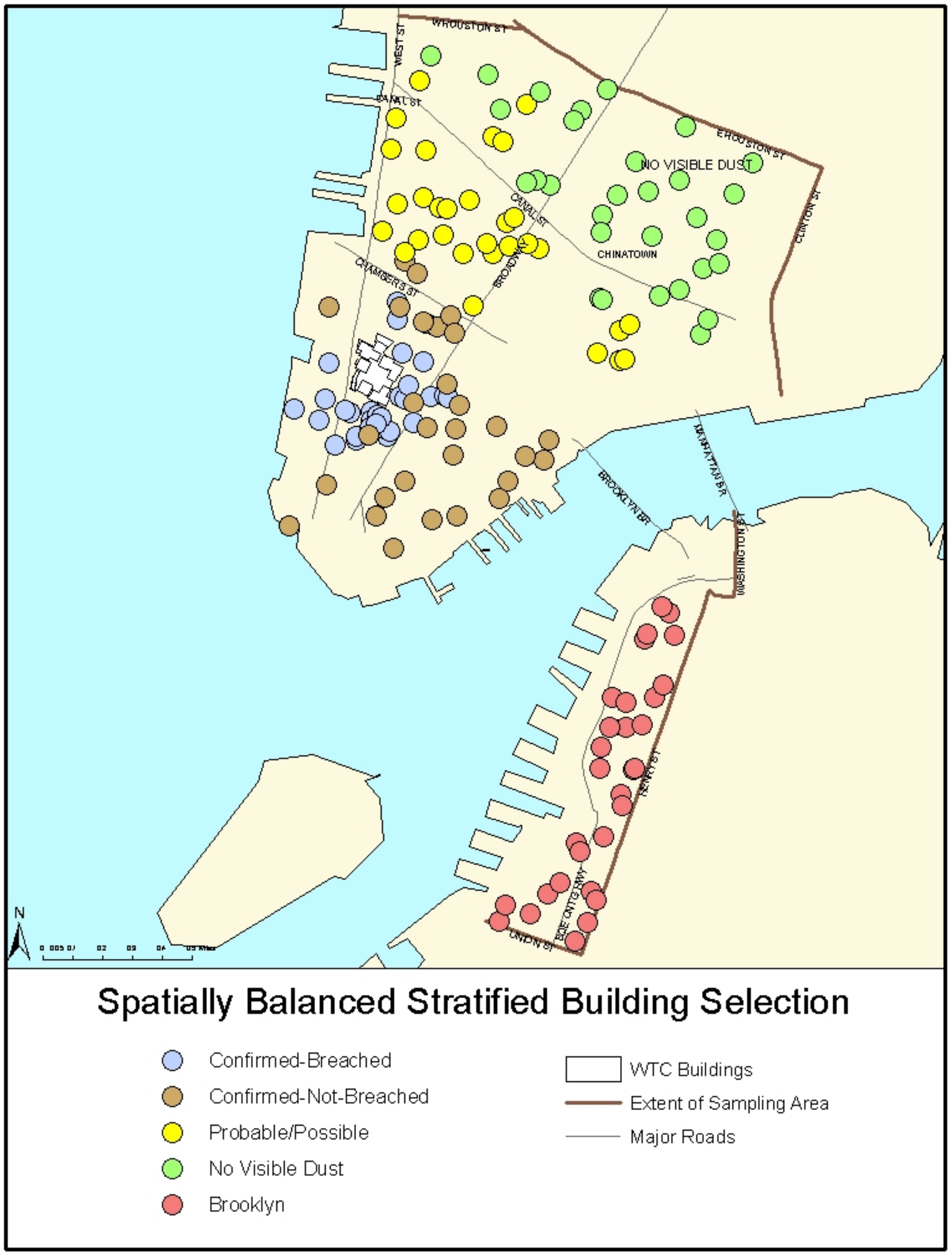


**Figure 3.** Example of possible outcome of a spatially balanced approach to building selection .

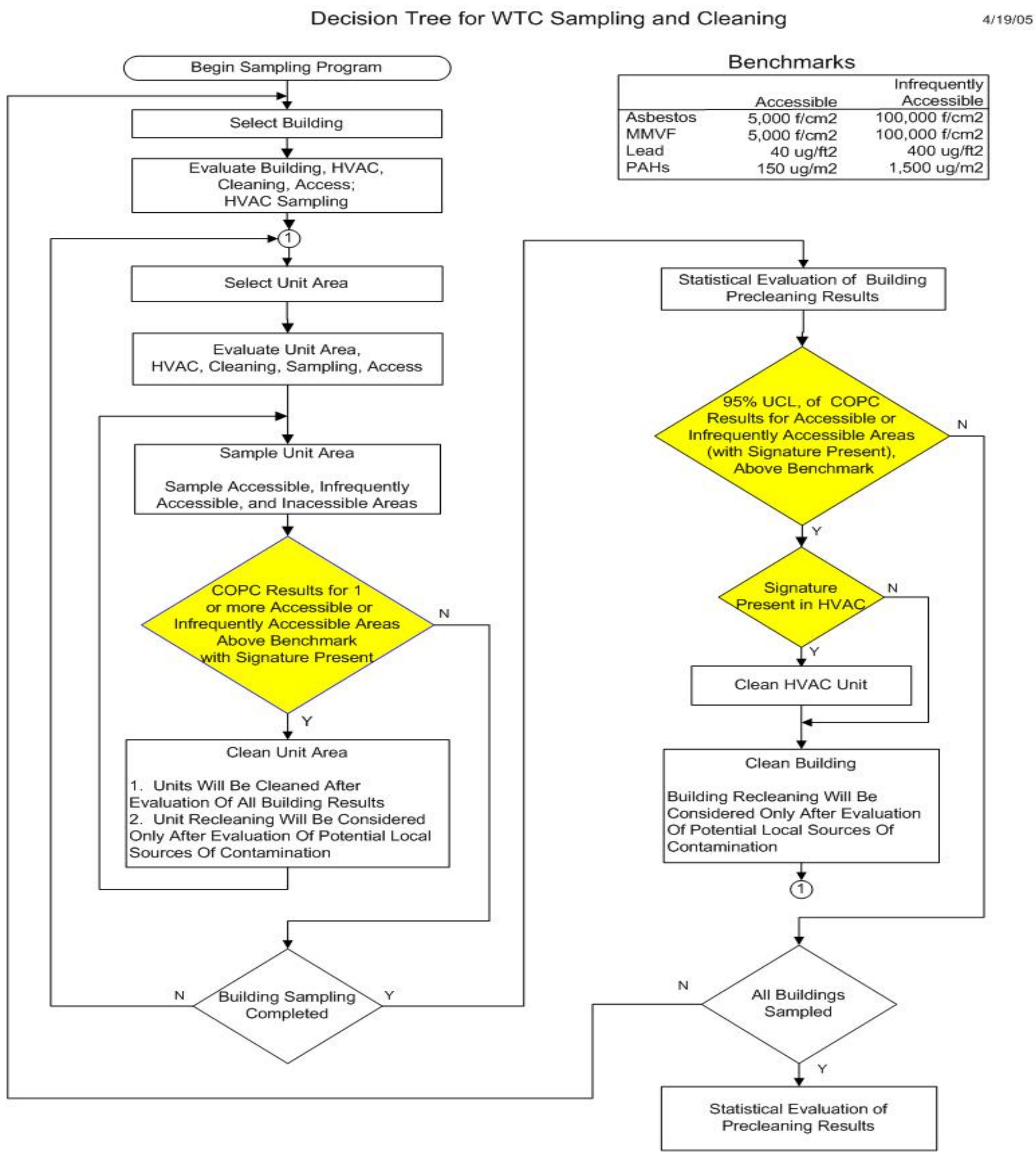


**Figure 4.** Decision tree for WTC sampling and cleaning.

**Table 1.** Summary Statistics for Buildings in Zones

| DUST ZONE | NBR_BLDGS | FLOORS | | | | Year BUILT | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | NBR BLDGS with DATA | RANGE | | | NBR BLDGS with DATA | RANGE | | |
| | | | Min | Max | Average | | Min | Max | Average |
| CONFIRMED-BREACHED | 53 | 48 | 2 | 58 | 17 | 45 | 1900 | 1993 | 1941 |
| CONFIRMED-UNBREACHED | 801 | 702 | 1 | 63 | 10 | 636 | 1857 | 2003 | 1928 |
| POSSIBLE | 946 | 894 | 1 | 53 | 6 | 772 | 1860 | 2003 | 1919 |
| NO DUST | 3269 | 3079 | 1 | 44 | 5 | 2214 | 1800 | 2003 | 1913 |
| BROOKLYN | 1313 | 1296 | 1 | 29 | 4 | 1122 | 1800 | 2003 | 1902 |

**Table 2. Building Database Description** (source, NYC Department of Housing Preservation)

| Seq # | Table, Function or Store Pro. Name | Column Name | Data field | Position | | Comments |
|---|---|---|---|---|---|---|
| 1 | BLDG | BLDG_ID | NUMBER(10) | 001 | 010 | A unique number assigned by HPD to each building for identification. |
| 2 | BLDG | PIN | NUMBER(10) | 012 | 021 | Premises identification number. This number is an internally used HPD reference. |
| 3 | BLDG | BIN | NUMBER(9) | 023 | 031 | Internal ID used by Department of Buildings. |
| 4 | DDW_BORO | BORO | CHAR(1) | 033 | 033 | Each borough is assigned a number. 1-Manhattan, 2-The Bronx, 3-Brooklyn, 4-Queens and 5-Staten Island. |
| 5 | BLDG | BLK | CHAR(5) | 035 | 039 | An individual area of land which is usually enclosed by city streets. Each block is assigned a unique identification number by the Department of Finance. |
| 6 | BLDG | LOT | CHAR(4) | 041 | 044 | An individual parcel or a plot of land. Each lot is assigned a unique identification number by the Department of Finance. |
| 7 | BLDG | COMU_DIST(CD) | NUMBER(3) | 046 | 048 | A unique number assigned to each Community District. |
| 8 | BLDG | CNSUS_TRCT | CHAR(6) | 050 | 055 | A relatively permanent statistical subdivision of a county in a metropolitan area, delineated by a committee of census data users for the purpose of presenting decennial census data. Census tract boundaries normally follow visible features, but may follow governmental unit boundaries. |
| 9 | BLDG | PHN | CHAR(12) | 057 | 068 | Primary House Number - Street number where the building is located. |
| 10 | BLDG | STR_NM | CHAR(32) | 070 | 101 | Street number where the building is located. |
| 11 | BLDG | RANGE | CHAR(25) | 103 | 127 | Range of addresses (lowest street number – highest street number) by which the property is known.<br>Concatenate Function<br>(low hus_no\|\|',' \|\|High_us_no) |
| 12 | BLDG | ZIP | CHAR(9) | 129 | 137 | Zip Code |
| 13 | BLDG | MDR_NO | NUMBER(10) | 139 | 148 | Multiple Dwelling Registration Number - A unique number assigned by HPD to individual apartment buildings. |
| 14 | BLDG | LEGL_CLAS_A_APTS | NUMBER(6) | 150 | 155 | "A" units are dwellings used, as a rule, for permanent residences. The typical residential apartment is an "A" unit. |

<table>
<tr><td>15</td><td>BLDG</td><td>LEGL_CLAS_B_APTS</td><td>NUMBER(6)</td><td>157</td><td>162</td><td>“B” units are dwellings used, as a rule, on a temporary basis.</td></tr>
<tr><td>16</td><td>BLDG</td><td>LEGL_STRYS</td><td>NUMBER(3)</td><td>164</td><td>166</td><td>The number of stories or floors in the building.</td></tr>
<tr><td>17</td><td>DDW_BLDG_ CLAS</td><td>BLDG_CLAS</td><td>CHAR(50)</td><td>168</td><td>217</td><td>HPD’s internal building classification. The following are the codes and their definitions.
<table>
<tr><td>A</td><td>OLD LAW TENEMENT</td></tr>
<tr><td>B</td><td>NEW LAW TENEMENT</td></tr>
<tr><td>C</td><td>OLD LAW SINGLE ROOM OCCUPANCY</td></tr>
<tr><td>D</td><td>NEW LAW SINGLE ROOM OCCUPANCY</td></tr>
<tr><td>E</td><td>HEREAFTER ERECTED CLASS A</td></tr>
<tr><td>F</td><td>HERETOFORE ERECTED EXISTING CLASS A</td></tr>
<tr><td>G</td><td>HERETOFORE CONVERTED CLASS A</td></tr>
<tr><td>H</td><td>HEREAFTER CONVERTED CLASS A</td></tr>
<tr><td>I</td><td>JOINT RESIDENTIAL/ARTISTS</td></tr>
<tr><td>J</td><td>CONVERTED OLD LAW TENEMENT</td></tr>
<tr><td>K</td><td>CONVERTED NEW LAW TENEMENT</td></tr>
<tr><td>L</td><td>LODGING HOME</td></tr>
<tr><td>M</td><td>Y-TYPE BUILDING</td></tr>
<tr><td>N</td><td>HEREAFTER ERECTED CLASS B</td></tr>
<tr><td>O</td><td>HERETOFORE ERECTED EXISTING CLASS B</td></tr>
<tr><td>P</td><td>HERETOFORE CONVERTED CLASS B</td></tr>
<tr><td>Q</td><td>HEREAFTER CONVERTED CLASS B</td></tr>
<tr><td>R</td><td>COMMERCIAL ALTERED CLASS B</td></tr>
<tr><td>T</td><td>TEMPORARY CERTIFICATE OF OCCUPANCY</td></tr>
<tr><td>W</td><td>COMMERCIAL ALTERED CLASS A</td></tr>
<tr><td>Y</td><td>CONVERTED DWELLING</td></tr>
<tr><td>7</td><td>INTERIM MULTIPLE DWELLING</td></tr>
<tr><td>X</td><td>PD GARDEN/MASONETTE</td></tr>
<tr><td>9</td><td>1 FAMILY HOUSE</td></tr>
</table></td></tr>
</table>

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | N/A NOT AVAILABLE<br>8 2 FAMILY HOUSE |
| 18 | PROG | PROG_SHRT_NM | CHAR(15) | 219 | 233 | Management Program<br>Indicates if the property is privately owned(PVT) or publicly owned. |
| 19 | BLDGLOAD_DT1 OR BLDGLOAD_DT2 | LAST_INSP_DT | CHAR(8) | 235 | 242 | (2) FUNCTION, Last Inspection date |
| 20 | BLDGLOAD_ERP | ERP_REPAIR_IND | CHAR(1) | 244 | 244 | FUNCTION, Emergency Repair Program Indicator |
| 21 | BLDGLOAD_DT3 | LAST_ERP_DATE | CHAR(8) | 246 | 253 | FUNCTION, Date of last Emergency Repair Program |
| 22 | STR_CODE | STR_CODE | CHAR(5) | 255 | 259 | Street Code |
| 23 | BLDG | YR_BUILT | CHAR(4) | 261 | 264 | Year Built |
| 24 | BLDG | DOF_BLDG_CLASS | CHAR(2) | 266 | 267 | Department of Finance Building Classification Code (see table) |
| 25 | DOF_BLDG_CLASS | DOF_BLDG_CLAS_DESC | CHAR(60) | 269 | 328 | Department of Finance Building Classification Description |
| | | | | | | |
| | | | | | | |
| | | **TOTAL** | **304** | **328** | | |

**Table 3.** Building Database Description – Building Classifications

| DOF_BLDG_CLASS | DOF_BLDG_CLAS_DESC |
|---|---|
| | |
| A1 | One Family House/Two Story Detached |
| A2 | One Family House/One Story |
| A3 | One Fam House/Large suburb Res |
| A4 | One Fam House/City Residence |
| A5 | One Fam/Attach or Semi-Detached |
| A7 | One Family/Mansion or Town House |
| A9 | One Family/Miscellaneous |
| B1 | Two Family/Brick |
| B2 | Two Family/Frame |
| B3 | Two Fam/Convert from One Family |
| B9 | Two Family/Miscellaneous |
| C0 | Walk-Up Apts/Three Families |
| C1 | Over Six Families w/o Stores |
| C2 | Walk-Up Apts/3 to 6 Families |
| C3 | Walk-Up Apts/Over 6 Families |
| C4 | Walk-Up Apts/Old Law Tenements |
| C5 | Converted Dwelling/Rooming House |
| C6 | Walk-Up Apt/Cooperatives |
| C7 | Walk-Up Over 6 Fam w/Stores |
| C8 | Co-Op Convert from Loft/Wareho |
| C9 | Walk-Up Apt/Miscellaneous |
| D0 | Elevator Apartments |
| D1 | Elev Apts/Semi-Frprof W/0 Store |
| D2 | Elev Apts/Semi-Frprof W/0 Store |
| D3 | Elevator Apts/Frprof W/0 Store |
| D4 | Elevator Apt/Co-ops(no Condos) |
| D5 | Elevator Apts/Converted |

| | |
|---|---|
| D6 | Elev Apts/Fireproof(w/Stores) |
| D7 | Elev Apts/Semi-Frprof w/Stores |
| D8 | Elevator Apts/Luxury Type |
| D9 | Elevator Apts Miscellaneous |
| E1 | Warehouses/Fireproof |
| E3 | Warehouses/Semi-Fireproof |
| E4 | Warehouses/Frames |
| E9 | Warehouses/Miscellaneous |
| F1 | Heavy Manufacturing(fireproof) |
| F2 | Factory/Industry/Spec. Construction |
| F4 | Factory/Industry/Semi-Fireproof |
| F5 | Fact/Indust/Light Manufacturing |
| F8 | Factory/Industry Tank Farms |
| F9 | Factory/Industry Miscellaneous |
| G0 | Garage and Gasoline Stations |
| G1 | Garage - Two or More Stories |
| G2 | Garage/One Story |
| G3 | Garage and Gas Station Combine |
| G4 | Gas Sta w/Enc Lube Plant/Wkshop |
| G5 | Gas Sta wo/Enc Lube Plant/Wkshop |
| G6 | Licensed Parking Lot |
| G7 | One or Two Car Garage |
| G8 | Garage with Showroom |
| G9 | Miscellaneous |
| H1 | Hotel/Lux Type Prior to 1960 |
| H2 | Hotel/Lux Type Built After 1960 |
| H3 | Hotel/Transient Occu Mdtown Ma |
| H4 | Hotel/Motels |
| H5 | Hotels/Private Club |
| H6 | Hotels/Apartments Hotels |
| H7 | Hotels/Apartments Hotels Co-op Owned |

| | |
|---|---|
| H8 | Hotels/Dormitories |
| H9 | Hotels/Miscellaneous |
| I1 | Hosp |
| I2 | Hospitals & Health/Infirmary |
| I3 | Hospitals and Health/Dispensary |
| I4 | Hospitals & Hlth/Staff Facilities |
| I5 | Hlth Centr |
| I6 | Hospitals & Health/Nursing Home |
| I7 | Hospitals/N.A. |
| I9 | Hospitals & Hlth/Miscellaneous |
| J1 | Theatr/Art Type under 400 Seats |
| J2 | Theater/Art Type over 400 Seats |
| J3 | Motion Picture Theatrew/Balcony |
| J4 | Legitimate Theatres |
| J5 | Theatr part of Bldg of other Use |
| J6 | Theaters/T.V. Studios |
| J7 | Theaters/Off Broadway Type |
| J8 | Multi-Motion Picture Theatre |
| J9 | Theaters/Miscellaneous |
| K1 | One Story Store Building |
| K2 | Two Story or Store and Office |
| K3 | Department Stores |
| K4 | Stores/With Apartments Above |
| K5 | Diners |
| K7 | Funeral Home |
| K9 | Store Bldgs/Miscellaneous |
| L1 | Loft Bldgs/over 8 Stories |
| L2 | Lofts/Fireproof & Storage Type |
| L3 | Loft Bldgs/Semi-Fireproof |
| L8 | Loft Bldgs/with Retail Stores |
| L9 | Loft Bldgs/Miscellaneous |

| | |
|---|---|
| M1 | Church |
| M2 | Mission House (Non-Residental) |
| M3 | Paronage |
| M4 | Convents |
| M9 | Churches Synagogues/Misc. |
| N1 | Asylums |
| N2 | Home/Indigent Kidgs |
| N4 | Detention Houses Wayward Girls |
| N9 | Asylums and Homes/Misc |
| O1 | Office Big/Fireproof to 9 Stores |
| O2 | Office Big/10 Fls & Over/Side St |
| O3 | Office 10 Fls & Over/Main Av |
| O4 | Office Bldg/Tower Type |
| O5 | Office Bldg/Semi-Fireproof |
| O6 | Bank Bldg Exclusively for Bank |
| O7 | Professioal Office Building |
| O8 | Office Bldg/with Res Apts |
| O9 | Office Bldgs/Misc. |
| P1 | Concert Halls |
| P2 | Lodge Rooms |
| P3 | YWCA |
| P4 | PAL |
| P5 | Community Center |
| P6 | Amusement Place |
| P7 | Museum |
| P8 | Library |
| P9 | Misc |
| Q1 | Parks |
| Q2 | Playgrounds |
| Q3 | Outdoor Pools |
| Q4 | Beaches |

| | |
|---|---|
| Q6 | Stadium |
| Q7 | Tennis Courts |
| Q9 | Recreation Facilities/Misc |
| R0 | Condominiums |
| R1 | Condos/One Family(Attached) |
| R2 | Condos/Walk-up Apartments |
| R3 | Condos/ 1-3 Story Condo |
| R4 | Condos/Apt Building W/Elev |
| R5 | Condos/Commercial Bldgs |
| R6 | Condos/Apt/N.A. |
| R8 | Condos/Apt/N.A. |
| R9 | Condos/Miscellaneous |
| S0 | Residential Multi Use |
| S1 | Multi Use/1 Fam w/Store or Ofc |
| S2 | Multi Use 2 Fam w/Store or Ofc |
| S3 | Prime 3 Fam w/Store |
| S4 | Prime 4 Fam w/Store |
| S5 | Prime 5-6 Fam w/Store |
| S9 | Prime Fam/N.A. |
| T1 | Airport |
| T2 | Piers |
| T9 | Transportation Facilities/Misc. |
| U1 | Bridges |
| U2 | Electric Utilities |
| U4 | Telephone Utilities |
| U6 | Railroads |
| U7 | Transportation |
| U8 | Revocable Consents |
| U9 | Utility Bureau Props/Misc. |
| V0 | Vacant Land |
| V1 | Vacant Land |

| | |
|---|---|
| V2 | Vacant Land/Police Dept |
| V3 | Vacant Land/Hospital |
| V4 | Vacant Land/Fire Dept |
| V5 | Vacant Land/School Site or Yar |
| V6 | Vacant Land/Library or Museums |
| V7 | Vacant Land/Port Authority |
| V8 | Vacant Land/State & Feds |
| V9 | Vacant Land/Misc. |
| W1 | Public Elementary Jr & Sr HS |
| W2 | Parachial Schools |
| W3 | Schools or Academies |
| W4 | Training Schools |
| W5 | City University |
| W6 | Other Colleges and Universities |
| W7 | Theological Seminaries |
| W8 | Other Private Schools |
| W9 | Education Structures/Misc |
| Y1 | Gov't Installations/Fire Dept |
| Y2 | Gov't Installations/Police Dept |
| Y3 | Gov't Instal/Prisons |
| Y4 | Gov't Instal/Military and Naval |
| Y5 | Gov Instal/Dept of Real Estate |
| Y6 | Gov't Installation/Dept of Sanitation |
| Y7 | Dept of Marine & Aviation |
| Y8 | Dept of Public Works |
| Y9 | Dept of Gas |
| Z1 | Court House |
| Z2 | Public Speaking Areas |
| Z3 | Post Office |
| Z4 | Foreign Governments |
| Z5 | United Nations |

| | |
|---|---|
| Z6 | Land Under Water |
| Z7 | Easements |
| Z8 | Cemeteries |
| Z9 | Other |

**Table 4. Proposed Sampling and Analytical Methods for the Building Sampling Program.**

| I. Proposed Sampling Scheme | | | | |
|---|---|---|---|---|
| **Type of Location** | **Locations** | **Samples to be collected** | **Description** | **Number of Samples** |
| Accessible | 1 a counter or table top, 2 floor or carpet in the main entrance used for access and egress from the building, 3a floor or carpet in the center of the most frequently used room or play area for children under the age of six; or 3b floor or carpet in a route of high traffic flow (i.e., stairs, hallway, etc.) if no children | 1 microvac, 1 PAH wipe, 1 Metal Wipe at each of the locations | microvac sample analyzed for MMVF, asbestos, PAH wipe for suite of congeners, Metal wipe for metals suite, | scaled to floor area as follows: <1000sf = 3 samples, >1000 <5000sf =5samples, >5000sf =7 samples, >10000sf =10 samples |
| Infrequently Accessed | On top of an infrequently cleaned object such as a refrigerator, bookcase or high chest of drawers, or other infrequently cleaned object | 1 microvac, 1 PAH wipe, 1 Metal Wipe at each of the locations | microvac sample analyzed for MMVF, asbestos, PAH wipe for suite of congeners, Metal wipe for metals suite, | scaled to floor area as follows: <1000sf = 3 samples, >1000 <5000sf =5samples, >5000sf =7 samples, >10000sf = 10 samples |
| Inaccessible | sample behind, below or above infrequently moved objects | 1 composite HEPA | HEPA sample analyzed for MMVF, asbestos, PAH suite of congeners, metals suite, and signature | scaled to floor area as follows: <1000sf = 3 locations, >1000 <5000sf =5 locations, >5000sf =7 locations, >10000sf only one composite regardless of area |
| HVAC | Inlet | one HEPA | HEPA composite sample analyzed for MMVF, asbestos, PAH suite of congeners, metals suite, and signature | assume 1 per bldg |
| | Filter | 1 Bulk Sample | Bulk sample analyzed for asbestos, MMVF, PAH suite, metals suite and signature, | assume 1 per bldg |
| | Mixing Plenum or other dead zone on each floor sampled | one HEPA | HEPA composite sample analyzed for MMVF, asbestos, PAH suite of congeners, metals suite, and signature | assume 1 per bldg |
| | Outlets in unit where samples are collected. | one HEPA | HEPA composite sample analyzed for MMVF, asbestos, PAH suite of congeners, metals suite, and signature | assume 1 per bldg |

| **II. Analytical Parameters for Each Sample** | | | | | |
|---|---|---|---|---|---|
| **Sample** | **Analytical Parameters** | **Sampling Method** | **Description** | **Analytical Method** | **Benchmarks** |
| Metal Wipe | Lead | HUD Appendix 13.1 | Wipe Samples. | SW-846 6010B | Accessible loading 40 µg/ft$^2$ Infrequently Accessed loading 400 µg/ft$^2$ |
| PAH Wipe | PAHs | ASTM D 6661-01 | Wipe Samples. | ASTM 6661-01/SW-846 8270C | Accessible loading 150 µg/m$^2$ Infrequently Accessed loading 1.5 mg/m$^2$ |
| Microvac | Asbestos | ASTM D 5755-95 | Microvac sample | ASTM D 5755-95 | Accessible loading 5000 structures/cm$^2$, Infrequently Accessed/HVAC 100000 structures/cm$^2$ |
| | MMVF | ASTM D 5755-95 | Microvac sample | SEM/EDS | Accessible loading 5000 structures/cm$^2$, Infrequently Accessed/HVAC 100000 structures/cm$^2$ |
| HEPA and Bulk Samples | Asbestos/MMVF | Bulk | HEPA and HVAC unit filters (collection of bulk dust sample from inaccessible areas, inlets,air filters,mixing plenums and outlets). | PLM NYS 198.1 followed by TEM NYS 198.4 | None |
| | Lead | Bulk | HEPA and HVAC unit filters (collection of bulk dust sample from inaccessible areas, inlets,air filters,mixing plenums and outlets). | SW-846 6010B | None |
| | PAHs | Bulk | HEPA and HVAC unit filters (collection of bulk dust sample from inaccessible areas, inlets,air filters,mixing plenums and outlets). | SW-846 8270 | None |
| | Signature | Bulk | HEPA and HVAC unit filters (collection of bulk dust sample from inaccessible areas, inlets,air filters,mixing plenums and outlets). | SEM/EDS | None |